



Air Force Research Laboratory Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio

Summer 1998

New Consortium Expands Aluminum Metal Matrix Composites Applications

A consortium, conceived and championed by engineers at the Air Force Research Laboratory Materials and Manufacturing Directorate, has been formed to expand the use of discontinuous reinforced aluminum (DRA) and provide lighter weight, more durable and less expensive products throughout the aerospace, automotive, electronics and recreational equipment industries.

The Aluminum Metal Matrix Composites Consortium (ALMMC) seeks to create and expand technology programs that improve manufacturing processes required to provide those products. Sixty-three representatives from commercial industry, government and academia from the United States, Canada and Japan attended the consortium's kick-off meeting in San Antonio, Texas, in February.

DRA materials (aluminum matrix reinforced with ceramic particles, whiskers or short fibers) have the potential of redefining the limits of aluminum materials because of their unique combinations of properties. They have the stiffness of titanium, better wear resistance than steel, and tailorable coefficient of thermal expansion, all while maintaining the lightweight characteristics of aluminum.

"Creative solutions to several remaining manufacturing technology and design issues are needed in order to realize the full market potential of DRA materials," according to Dr. Benji Maryuama, of the Air Force Research Laboratory Materials and Manufacturing Directorate. "Production and component costs must be lowered, and while adequate for current parts, manufacturing knowledge for DRA needs to be expanded to broaden the range of potential applications." Additionally, while successful products have been designed

and implemented, the information that would enable extension of these successes to other products and markets is not widely accessible.

The ALMMC Consortium was created to tackle these challenges. The initial focus of the consortium is on technology development programs to address manufacturing technology needs in specific areas, and on providing assistance to the user and producer communities. The consortium's efforts to develop low-cost processing methods provide a potential for significantly expanded use. Examples of successful applications of DRA abound in the aerospace, automotive, electronic packaging, and recreational product markets. Specific examples include: Chevrolet Corvette and General Motors S/T pick-up truck drive shafts; Plymouth Prowler brake rotors and General Motors EV-1 brake drums; Honda Prelude cylinder liners; Pratt & Whitney 4000 series engine fan exit guide vanes; Motorola's Iridium Satellites; General Motors EV-1 electronic packaging applications; F-16 fighter aircraft ventral fins and fuel access covers; bicycle components; and golf clubs from a variety of producers.

An important thrust of the program is the establishment of a "User Resource Center" to provide expert advice and referrals to prospective DRA users and suppliers; promote DRA materials, products and capabilities; and create an industry "presence" through products such as an "ALMMC Resource Directory." Dr. Maryuama concluded that "this consorted effort will provide viable, low-cost manufacturing technologies for DRA and will expand the use of this lightweight, durable material and ultimately be an asset for the Air Force and commercial industry."

Last Issue of Materials Technology Highlights

This is the last issue of the Materials Technology Highlights as you know it.

As most readers of this publication are aware by now, the former Materials Directorate and Manufacturing Technology Directorate were combined to form the Materials and Manufacturing Directorate. The two former directorates had quarterly publications which were distinct, yet somewhat similar.

The Materials Technology Highlights, a four-page report published by the former Materials Directorate, highlighted some of the directorate's success stories and current initiatives, had a calendar of events, and listed recently completed and started contracts. The former Manufacturing Technology Directorate's Program Status Report, a 16-page document, similarly highlighted successes and current initiatives, described upcoming events, and projected contracts coming to completion. It also provided a listing of various reports and videos available.

In the interest of serving both audiences in the most efficient and economical manner, these publications are being combined to form a completely new product. This product will look somewhat different, but it will still contain articles on the directorate's successes, current initiatives, and upcoming events. Additionally, it will have more in-depth articles, and will evolve as necessary to serve the needs of the directorate.

Materials R&D Success Stories

Innovative Approach Eliminates Hazardous Waste Streams From Aircraft Parts Cleaning Process

A revolutionary approach for cleaning aircraft parts that eliminates environmentally hazardous waste streams has been developed by scientists and engineers at the Air Force Research Laboratory Materials and Manufacturing Directorate. The innovative approach combines two types of cleaning technology, dry ice pellet pre-cleaning and ultraviolet light (UV)/ozone cleaning, providing ultra-clean surfaces difficult to reproduce with standard cleaning techniques employing organic solvents.

Cleaning technologies for aircraft parts often depend on an organic solvent, aqueous solvent or blast cleaning media, resulting in large quantities of contaminated cleaning media which must be disposed of or treated. Environmental regulations pertaining to the disposal and treatment of these waste materials tend to make clean-up operations increasingly costly. Several current cleaning technologies circumvent this pollution problem by not generating any contaminated cleaning media. However, none of these techniques alone satisfies the cleaning requirements for aerospace parts cleaning.

Supported by funding from the Department of Defense Strategic Environmental Research and Development Program (SERDP), directorate scientists developed a new approach for parts cleaning. Their research showed that combining these two techniques more than meets the needs of the aerospace industry. The first technique, a dry ice pellet pre-clean, removes the bulk of the contaminants. The second technique, exposure to CO₂ ultraviolet (UV) light and ozone, produces an ultra-clean, water break-free surface. The dry ice pellet and UV/ozone combination has previously been highly effective for cleaning metal surfaces. In this present effort, researchers

extended the utility of both techniques to include the cleaning of complex parts, non-metallic parts and other objects prior to the application of optical and thermal protective coatings. They also developed a working engineering model that can be used to design new UV/ozone systems, further expanding the applications in the military and commercial sector. This approach could significantly reduce compliance and clean-up costs while enhancing worker safety.

Since the research program began in 1995, the UV/ozone technique has earned the prestigious Clean Air Technology Award presented annually by Union Electric Company for use of a new

technology that will significantly reduce air pollution. This cleaning technique has also been transitioned to the Navy, which in a follow-on effort plans to use the dry ice pellet and UV/ozone techniques to improve thermal protective coatings on firefighter helmet shields. Other applications are currently being considered by the Air Force and commercial industry.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 97-197.



CO₂ ultraviolet light/ozone cleaning chamber

MATERIALS AND MANUFACTURING TECHNOLOGY SERIES

The Air Force Research Laboratory (AFRL) Materials and Manufacturing Directorate (ML) leads a partnership of Air Force, government, industry, higher education, and professional society organizations in trying to foster interaction among materials and manufacturing scientists, engineers and others.

Their Materials and Manufacturing Technology Series provides a forum for presentations by leading scientists, engineers and managers, and an opportunity to share their ideas on the future of materials and manufacturing technology.

Recent guest speakers have included: Dr. John H. Hopps Jr., Provost and Senior Vice President of Academic Affairs at Morehouse College, in Atlanta, Ga.; Dr. Steven Chu, one of the winners of the 1997 Nobel Prize in Physics; and Dr. Arthur Fry, chemical engineer at the 3M Company who developed the "Post-It" note. Scheduled upcoming gatherings include a presentation on Nano-Technology July 30, a briefing by Dr. James Womack on Lean Thinking Sept. 24, and a session on the Future of Microelectromechanical Systems by Dr. Hans Zappe Oct. 30.

For more information or to register, visit "www.ml.wpafb.af.mil/mmts" or call (937) 426-2808.

Visit us at www.afrl.af.mil

Low-Cost Composite Processing Improves Affordability of Aerospace Structures

Engineers and scientists at the Air Force Research Laboratory Materials and Manufacturing Directorate have demonstrated the ability to lower the cost of applying organic matrix composite materials to aerospace structures. The results of their "Low Cost Composite Processing" (LCCP) research showed a 40 percent reduction in fabrication costs for a composite fighter aircraft wing using non-autoclave processing versus conventional processing methods.

Conventional aerospace composites typically require large investments in equipment and tooling to ensure structural performance that meets the demanding criteria of modern military aircraft. For high-volume aircraft production programs, capital investment costs and autoclave-hardened tooling required for traditional composite processing can be amortized over a large number of aircraft.

Fabrication of high-performance composite structures on a low-volume basis leads to high costs. Even advanced, automated composite processes such as fiber placement and resin transfer molding require investments in equipment, tooling and programming which, when amortized over fewer units, reduce the cost advantages of automation. Additionally, equipment size limitations and tooling complexities associated with traditional composite processing can stifle innovative design concepts which could dramatically reduce assembly costs by minimizing the parts count. The economic viability of low-volume programs depends, in part, on reducing production costs.

The LCCP program focused on lowering the cost of organic matrix composites through non-autoclave processing to achieve more affordable prototype and low-volume aerospace structures. The performance criteria for these leading edge vehicles are as demanding as for the existing state-of-the-art aircraft. Often, strength, weight and reduced signature requirements can only be met through extensive use of composite materials. Affordability has become a key factor in the viability of advanced programs, creating a need for more affordable composite processing techniques.

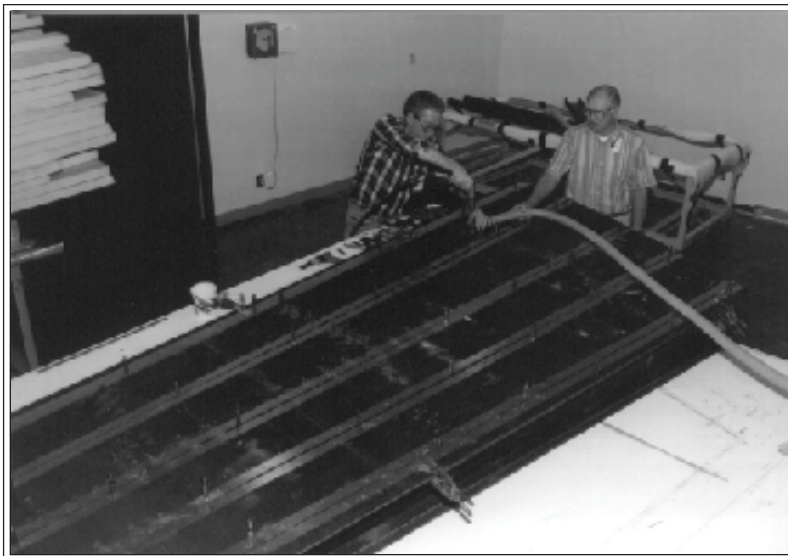
LCCP addressed this need by departing from traditional aerospace composite processing concepts and eliminating the need for expensive autoclaves and hardened tooling to fabricate high-performance composite structures. This was enabled by the development of composite materials that can be processed at low temperatures and pressures. The primary goal

was to identify and develop high-performance composite material systems which could match the structural capability of current aerospace-grade systems and which could be processed at low temperature (i.e., 150 degrees F) and vacuum pressure.

In Phase I, materials requirements were established; potential composite material systems, film adhesives and wet resin systems screened; allowables generated for the most promising systems; and low cost tooling concepts developed. Although neither of the first-generation systems completely met the structural performance goals, they did demonstrate credible performance, which strongly suggests that second-generation systems could reach and possibly exceed the program goals. This also suggests potential near-term payoffs for unmanned air vehicles or launch vehicles. Significantly lower-cost fabrication methods using non-autoclave processing were demonstrated during Phase II. Key concepts were validated by fabricating and testing elements from a composite wing torquebox and by fabricating several demonstration articles. As a final demonstration of affordability gains, a co-bonded wing assembly was designed and fabricated in Phase III.

LCCP-developed materials and processing technology have demonstrated significant promise in terms of improved affordability of composite structures for aerospace applications. Continued efforts in related non-autoclave processing technology could lead to significant cost reductions as well as the successful production of large, complex, one-piece composite structures without the size and thermal constraints of an autoclave.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 98-087.



(Top) Styrofoam oven (Bottom) Technicians at work on wing assembly constructed with composite materials

CALENDAR OF EVENTS

Manufacturing Technology for Tactical Fiber
Optic Gyroscopes Review
July 22, Salt Lake City, UT

Polymer Workshop: Polymer Materials and
Films for Space Structures
July 24, WPAFB, OH

1998 National Fire Control Symposium
August 3-6, San Diego, CA

1998 Air Force NDI Working Group Meeting
August 3-6, San Antonio, TX

Infrared Materials & Detectors
IRIS Conference
August 10-13, Boulder, CO

Metal Forming Tool Design Demonstration
August 25, WPAFB, OH

Small Business Innovation Research Industry
Days
September 2-3, WPAFB, OH

Materials & Manufacturing Technology Series
July 30, Wright State Univ, Dayton, OH
September 24, Sinclair Community College,
Dayton, OH

1998 National Space & Missile Materials
Symposium
October 19-22, Colorado Springs, CO

NEW CONTRACTS

- Coating and Plating Processes For High Thermal Performance Composites - F33615-98-C-5026
- Durable Fluorocarbon-Based Coatings For Aircraft - F33615-98-C-5028
- Novel High-Temperature Polymer/Inorganic Nanocomposites - F33615-98-C-5029
- Performance Eval Of Improved Lubricants For Tribological Systems Of Future Spacecraft - F33615-98-C-5031
- Advanced Performance Coating Degradation Mechanisms - F33615-98-C-5033
- Corrosion Protection Coatings For Aluminum - F33615-98-C-5034
- Multifunctional Coupling Layer For An Advanced Coating System - F33615-98-C-5035
- Multiscale Modeling Including Micromechanical Failure Prediction - F33615-98-C-5037
- Polymer-Modified Ceramics For Composite Airframe With Improved Ballistic Resistance - F33615-98-C-5039
- Lightweight Tankage Materials For Military Space Plane Applications - F33615-98-C-5040
- Lightweight, Low Thermal Conductivity Thermal Protection System - F33615-98-C-5041
- Novel Composite Materials For The Manufacture Of Functionally Graded Structures - F33615-98-C-5042
- Functionally-Graded Thermoplastic Tubes Fabricated Via Pulsed Spray Forming - F33615-98-C-5043
- New Thermoplastic Elastomer Matrix Resins For Advanced Aircraft Sealants - F33615-98-C-5044
- Matrix Materials For High Performance High Adhesion Sealants And Gap Fillers - F33615-98-C-5045
- Interactive Simulation System For Design Of Multi-Stage Material Processes - F33615-98-C-5114
- Weapon Systems Integration Cost Model, An Automated Method For Affordability Eval - F33615-98-C-5118
- Nanostructured Photocatalyst For VOC Mineralization - F33615-98-C-5123
- Heterogeneous Catalysts For Near-Ambient Temperature Destruction Of Volatile Organic Compounds - F33615-98-C-5124
- Multi-Layer Thin Film Coatings For Aluminum Alloy Components - F33615-98-C-5127
- Magnetoresistive, Remote-Field Eddy-Current Probe - F33615-98-C-5131
- Damage Detection In A/C Using Giant Magnetoresistance Sensor - F33615-98-C-5132
- Forecast/ABC: A Predictive Activity-Based Cost Modeling & Analysis Agent Network - F33615-98-C-5133
- Predictive Activity-Based Cost Modeling Agent Network - F33615-98-C-5134
- X-Ray Sensors For Real Time Control Of Thin Film Deposition - F33615-98-C-5135
- Thin Film Growth Simulation Using Cellular Methods - F33615-98-C-5138
- Integrated Substrate And Thin-Film Methods - F33615-98-C-5139
- Test Methods To Determine The Presence Of Halorespiring Subsurface Bacteria - F33615-98-C-5140
- Integration Of In-Situ, Real-Time Commercial, Soil, Groundwater Sensor Technologies With E-Smart - F33615-98-C-5141
- E-Smart Enabled Sensor Development - F33615-98-C-5142
- Development Of A Particulate Matter On-Line RT, Physical Chemical Characterization And Monitoring System - F33615-98-C-5143
- Sesame-Step Entry For Small & Medium-Sized Enterprises - F33615-98-C-5144
- Affordable, Improved Plastic Patterns For Precision Investment Castings - F33615-98-C-5145
- Brazed Aluminum Ribbon Composites Material For Cryogenic Tanks - F33615-98-C-5203
- Micro-Electro-Mechanical Systems Adhesive Bond Degradation - F33615-98-C-5204
- Advanced Field Use Instrument For Nondestructive Fatigue Damage Assessment And Remaining Service Life Prediction For Aging Aerospace Systems - F33615-98-C-5205
- Low Cost Precision Forming Of Discontinuously Reinforced Metal Matrix Composites - F33615-98-C-5206
- Robust Discontinuously Reinforced Aluminum Stator Vanes For Gas Turbine Engines - F33615-98-C-5207
- Affordable Ceramic Matrix Composites - F33615-98-C-5210
- Novel NDE Corrosion Rate Measuring System For Airframe Structural Integrity - F33615-98-C-5213
- Damage Tolerant Design Of Gamma TiAl - F33615-97-C-5291
- Advanced Rugate Development - II - F33615-97-C-5401
- Advanced Rugate Development - III - F33615-97-C-5402
- Novel Ferroelectric Liquid Crystal Polymers For Electro-Optic Device Applications - F33615-98-C-5414
- Real-Time Process Monitor For Growth Of Hi-Temperature Superconductor Thin Films - F33615-98-C-5416
- Low Cost, High Performance Superconducting Cable Via CCVD - F33615-98-C-5418
- Improved Buffers & Processing For Oriented YBCO On Biaxial Metal Tape - F33615-98-C-5419
- Electrostatic Self-Assembly Of Optical Limiting Coatings - F33615-98-C-5420
- Electrostatic Self-Assembly Processes For Linear & Nonlinear Optical Thin-Film Materials And Devices - F33615-98-C-5421
- Ultra-High Quality, Single Crystal Bulk Silicon Carbide - II - F33615-98-C-5422
- Low Temp Homo/Heteroepitaxial Growth Of SiC And Hexagonal Nb2C Substrates - F33615-98-C-5423
- Novel, Thick SiC Epitaxial Growth For Next Generation Power Devices - F33615-98-C-5424
- Growth & Testing Of AGGA(1-X) INSE2 For High Average Power Nonlinear Optics - F33615-98-C-5426
- Bulk Periodically-Poled Potassium Niobate Crystals For Mid-IR Opo Applications - F33615-98-C-5427
- Shelf-Stable, Low Temp Cure Epoxy Film Adhesive For On-Aircraft Bonded Repair - F33615-98-C-5652
- UV Activated, Thermally Cured Film Adhesive For On-A/C Bonded Repairs - F33615-98-C-5653
- High Temperature, Long Service-Life Fuel Cell Bladder Materials - F33615-98-C-5654
- High Temperature, Long Service-Life Fuel Cell Bladder Materials - F33615-98-C-5655
- Multi Co-Substrates For Biostimulation Of TCE Degradation - F33615-98-C-5850
- High Temp Heterogeneous Redox Catalysts For Nox Abatement - F33615-98-C-5851
- Attenuated Total Reflectance Sensor - F33615-98-C-5852

The USAF Materials Technology Highlights is published quarterly to provide information on materials research and development activities by Air Force Research Laboratory's Materials & Manufacturing Directorate. For more information on subjects covered in "Highlights" or to be added to the "Highlights" mailing list, contact the Materials & Manufacturing Directorate Technology Information Center at (937) 255-6469 or e-mail at techinfo@ml.wpafb.af.mil. Approved for Public Release (ASC/PA#98-1325).

AFRL/MLOP-TIC BLDG. 653
2977 P STREET, SUITE 13
WRIGHT-PATTERSON AFB OH 45433-7746

OFFICIAL BUSINESS